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WATER SUPPLY ENGINEERING

Report of Committee on Water Supply Engineering
of the Sanitary Engineering Division for the
Period Ending September 30, 1953

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WATER SUPPLY ENGINEERING

REPORT OF COMMITTEE ON WATER SUPPLY ENGINEERING OF THE SANITARY ENGINEERING DIVISION FOR THE PERIOD ENDING SEPTEMBER 30, 1953

The previous report of the Committee on Water Supply Engineering of the Sanitary Engineering Division was submitted at the Annual Meeting in October, 1951 and was published as Separate No. 164, Proceedings Vol. 79, January, 1953. Since that time Thomas H. Wiggin, M. ASCE and John R. Baylis, M. ASCE have resigned from the Committee. Each served on it many years and contributed much to the work of the Committee since it was established in 1933. The Committee wishes to express its appreciation of their generous contribution of time and effort to the work of the Committee since its inception. Since 1951 the following have been appointed as members of the Committee on Water Supply Engineering: Marshall P. Crabill, A.M. ASCE, Harvey F. Ludwig, A.M. ASCE, Thomas M. Niles, M. ASCE and Erman A. Pearson, A.M. ASCE.

The 1953 Report of the Committee covers trends, developments and events of interest to members of the water works profession, which have occurred during the period from October, 1951 to October, 1953.

Two of the trends which were noted in the 1951 Report have continued during the past two-year period. These are a general increase in per capita domestic water consumption and increased use of water for industrial purposes. These trends are believed to be the result of comparatively high levels of employment and income.

Another trend that has continued during the period is the increase in cost of water works operation, maintenance and construction. During the past few months this trend appears to be leveling off. It has resulted in many instances in the necessity of increasing water rates.

Although the period covered by this report has not witnessed any serious water shortages in municipal systems resulting from lack of supply, except in parts of the Southwest, peak water consumption during dry periods has caused low pressures and poor service in many communities. In general these conditions are caused by weak feeder mains and inadequate distribution storage facilities. The present tendency for increased construction of feeder mains and storage capacity must continue.

Rainfall during the period, except in the southwest and central parts of the country, has been comparatively normal. No unusual flood conditions have occurred.

The 1951 Report of this Committee described two different approaches to the problem of formulating a national water policy, or policies, one by the President's Water Policy Commission and the other by the Engineers' Joint Council (EJC). To date no action has been taken by the Administration or by Congress to adopt a definite water policy program. It has been suggested that a federal resources board be created to act as a coordinating agency and that the states and local interests should assume a larger share of the cost of water resources developments and in their initiation, planning, construction and operation. The recently appointed Committee for Reorganization of the Federal Government ("new Hoover Commission") will undoubtedly probe further into this subject.

The two-year period covered by this report has witnessed an exceptional

growth in the number of plants using fluoridation to reduce the development of dental caries. It has also been a period in which increased attention has been given to methods of controlling adverse effect of industrial wastes, including radioactive materials, on water supplies. These developments, and other recent items of interest in connection with sources of supply works, distribution systems, treatment works, and water analysis and testing, are described in the report.

Since the creation of the Federal Civil Defense Administration in 1951 the role of water works in civil defense has received increased attention. Technical Manual 13-2, "Operation and Repair of Water Facilities in Civil Defense Emergencies", published by the FCDA in September, 1953, recommends procedures for maintaining the quantity and safety of water supplies in communities subjected to attack by conventional and unconventional weapons including atomic, radiological, chemical, and biological warfare.

Sources of Water Supply

Ground Water

Continuation of drought conditions in the Southwest during the past two-year period has caused serious depletion of ground water supplies and intrusion of sea water in certain areas. This has given impetus to studies of recharging of underground storage and of the effects of sea water intrusion on ground water supplies.

The State of California has continued its comprehensive statewide investigation known as the "California Water Plan" which was mentioned in our 1951 report. Bulletin No. 1, "Water Resources of California" was published in July, 1951. It contains much information on ground water conditions. Additional studies through cooperative contracts with the United States Geological Survey of ground water levels, measurement of stream bed percolation and extent of present use of ground water are underway.

In 1951 the State of California appropriated $750,000 to its Water Resources Board for investigational work and study of methods and design criteria for the prevention of sea water intrusion into ground water basins. The project includes construction and testing of a number of injection wells of various types. Much more experimental work is necessary before conclusive results are attained (1).

A number of recent papers describe various methods for recharge and utilization of excess stream flows, sewage and industrial waste for augmenting underground water supplies (2) (3) (4) (5).

Ground water conditions in general throughout the past two-year period have been normal except for the southwest part of the country. This is shown by data in the monthly issues of Water Resources Review of the United States Geological Survey (USGS). As stated in the 1951 Report of this Committee, a very complete discussion of ground water supplies and conditions in the United States is contained in Geological Survey Paper No. 114 (6). An excellent general treatise on ground water which describes its use and misuse was published in 1951 (7).

Miscellaneous subjects of interest in connection with ground water supplies covered by recently published articles include descriptions of seismic and electrical methods for exploring underground conditions (8), use of explosives for improving wells (9), and installation and performance of radial collector wells (10).

Surface Water

Circular No. 15 of the United States Geological Survey contains interesting

statistical estimates of water consumption in the United States in 1950. Industrial use from private industrial supplies was estimated to be 77,000 mgd. Consumption of municipal water systems (public and private) was estimated to be 13,640 mgd, or an average of 145 gcd for 93-1/2 million consumers. Of the latter amount, 10,056 mgd were obtained from surface waters and 3,584 mgd from ground water supplies (11). These estimates, compared to previously published similar estimates and records of water consumption in various parts of the country, show two interesting trends: (a) a definite substantial increase in per capita water consumption, and (b) a much greater use of water by industry.

The needs and problems relating to industrial use of water are being studied by an American Water Works Association (AWWA) task group (12) and have been discussed by others within the past two-year period (13) (14).

Preliminary plans and estimates were presented in a report of the State Engineer of California in 1951 on the Feather River Project and surveys and preliminary designs are now underway. The project comprises a dam 710 feet high on the Feather River in northern California to form a storage reservoir of 3-1/2 million acre-feet from which water would be diverted by means of a system of tunnels, pumping and canals to supply the Feather River service area, Southern Alameda and Santa Clara Counties in the San Francisco area, the southern part of San Joaquin Valley and portions of Southern California south of the Tehachapi Mountains. The estimated cost of this large water supply project is about 1-1/2 billion dollars (15). A similar project for supplying dry areas in Southern California by means of a dam at the mouth of the Klamath River, diversion to the Sacramento River and successive pumping stations, canals and tunnels extending as far south as San Diego, has been considered. The estimated cost of this immense water supply project is $3-1/2 billion (16).

In the 1951 Report of this Committee, the 1949-50 shortage of water supply for New York City and plans for increasing the supply by 540 mgd by the first two stages of the Delaware-Roundout supply were discussed. Stage 1 of this project is in partial use and Stage 2 will be in use within the next two years (17). Inasmuch as development of the "Incodel" plan (18) for diverting upper Delaware River water to northeastern New Jersey and New York City was opposed by Pennsylvania (19), and a proposed plan for using the waters of the Hudson River was disapproved by the Board of Estimate (20) New York City is now planning a third stage of its Delaware River supply. It has applied to the Supreme Court of the United States to permit an increase in diversion from the Delaware River from 440 to 800 mgd by diverting water from the West Branch of the river at Cannonsville through a 25-mile tunnel to the Pepacton Reservoir now under construction on the East Branch of the Delaware. A Special Master was appointed to hear the case. After extensive testimony by the parties involved, an agreement was reached by them to recommend to the Special Master a method for division of the yield of the river (21). Up to the first of October, 1953, no report has been made by the Special Master. Unless there is a change in the attitude of Pennsylvania in favor of a tri-state project, it will be necessary for individual action of New Jersey and New York to develop additional supplies which are needed now by New Jersey and will be needed in a few years by New York City.

Additional surface water supplies under construction in the San Francisco area include the Big Carson Dam of the Marin Municipal Water District on the northwest side of San Francisco Bay and the Cherry Valley Dam which will be utilized for power, flood control, irrigation and for increasing the municipal supply of San Francisco.

The increase in use of water in various parts of the United States has stimulated plans for development of many additional surface water supplies.

Effect of Dry Periods

Drought conditions during the past two years throughout the Southwest have caused extensive agricultural damage and have resulted in the necessity of curtailing municipal and industrial water use. Record breaking hot and dry periods at Dallas in 1952 forced a reduction of water consumption of about 40 per cent (22). Dry periods of short duration were experienced in the early summer of 1952 and the late summer of 1953 in the central and eastern parts of the United States. These resulted in peak consumption which caused poor service and low pressures. In most cases this was because of inadequacies of distribution system facilities rather than depletion of sources of supply.

Effect of Wet Periods and Floods

In 1952 prolonged high water levels in the Great Lakes caused concern. Record monthly highs were reported in February for Lake Superior and in May and June for Lakes Erie and Ontario. On September 11, 1952, an extraordinary peak flow of 450,000 cfs from 947 square miles, or 474 cfs per square mile, was recorded on the Pedernales River near Johnson City, Texas. The same storm caused a high flow of 152.6 cfs per square mile from a drainage area of 5,500 square miles on the Colorado River at Lake Travis, Texas. Otherwise, there were no unusual flood conditions during 1952 and 1953 to date (23).

In our Report of 1951, reference was made to the disastrous flood of July, 1951 in the Kansas River Basin. Flood control plans comprising large storage reservoirs were proposed by the United States Bureau of Reclamation and the United States Corps of Reclamation and the United States Corps of Engineers prior to the 1951 flood and were recommended by the United States Corps of Engineers subsequent to the flood. A Board of Engineers engaged in 1952 by the Kansas Industrial Development Commission submitted a final report in June, 1953 in which they recommended as a substitute for the large storage reservoir plan, a plan of local protection works comprising channels, flow-ways and dikes designed to carry flows in excess of the 1951 flood. The Board claimed that this plan would be much cheaper and more effective than the large storage reservoir plan (24).

Efforts have been made to develop an overall body to supervise operation of completed projects and plans for future developments in the Missouri River Basin. In January, 1953, the Council of State Governments prepared for the Missouri River States Committee a revised draft of a Missouri River Compact which would provide for participation by the ten states of the region and by the federal government in the formulation of basic broad policy. It also proposed to utilize established governmental agencies for construction of facilities and in the operations of programs (25). These proposals are under consideration.

Erosion Control and Reservoir Silting

As stated in the 1951 Report of this Committee, the loss in storage capacity of reservoirs resulting from land erosion is substantial. A task group of AWWA has this subject under investigation and study. It submitted a preliminary report with an extensive bibliography in August, 1953 (26).

Sounding methods for sedimentation studies, including supersonic methods using echo sounders and direct measurement of sediment thickness, are described in a recent ASCE symposium (27).

Progress in Municipal Pollution Control

Progress in municipal pollution abatement during 1952, measured in dollar volume, was the lowest on record since 1948. (PHS Pub. 291, Public Sewage Treatment Plant Construction, 1952). The volume for the first half of 1953 was 39 percent higher than the corresponding period of 1952, indicating perhaps a reflection of greater material availability as the Nation moved toward completion of its defense buildup. Interest rates for municipal construction increased during the 2-year period from about 2 percent to slightly above 3 percent, but again turned downward during the Summer of 1953. (The Bond Buyer, October 17, 1953, Vol. 127, No. 9, Section II, p. 1, The Bond Buyer's Index --20 Municipals).

Progress in Industrial Pollution Control

There has been much progress in investigations and studies in industrial pollution control facilities during the past two-year period. Important new studies were the results of grants under the Federal Water Pollution Control Act for industrial waste investigations. Many new industrial establishments have incorporated extensive pollution control plants in the initial plant installation. Examples of these are the treatment plants of the United States Steel Corporation at Morrisville, Pennsylvania (28) and of the Link-Belt Company at Lansdale, Pennsylvania (29). No satisfactory method for determining actual progress by United States industry in the abatement of industrial pollution, comparable to the means available for measuring municipal pollution abatement has yet been developed.

The current work of the United States Public Health Service (USPHS) in conjunction with state agencies, the National Council for Stream Improvement, the Ohio River Commission, and the programs of New York, California and Pennsylvania in connection with pollution abatement were discussed in our 1951 Report. Considerable progress has been made during the past two-year period by these and other agencies in establishing general policies and in carrying out surveys, investigations and promoting actual design and construction.

The three-year report of the California Water Pollution Control Board on work accomplished since the passage of the 1949 Pollution Control Act provides an interesting and encouraging account of its activities in fact-finding, research and coordination (30). This Board also has published a comprehensive research report on water quality criteria (31).

The Ohio River Valley Water Sanitation Commission has recommended tax aid through early write-off of industrial waste pollution abatement (32). A survey of 1,939 industrial plants in the New England area by the New England Interstate Water Pollution Control Commission indicated an equivalent pollution load of 5 million people in the area with only 6.6 per cent of the industrial waste being treated (33).

Within the past two-year period there have been extensive investigations on methods for testing water for radioactive materials, the effect of radioactive materials on water supply systems and of methods of removing them. Equipment and methods for detecting radioactive materials in water are described in references (34) (35) (36). The significance and effect of radioactive wastes are covered in a number of recently published papers (37) (38) (39) (40). Standard settling and filtration methods of water treatment and biological methods of sewage treatment have been shown to be effective in removal of certain types of radioactive materials. In some instances special treatment

using powdered metal and other substances have been effective (41) (42). A review of the extensive literature describing research work and tests which have been accomplished and are under way provides assurance that cooperative efforts of the Atomic Energy Commission, research scientists and those in responsible charge of water supply systems can prevent the development of unsatisfactory conditions in public water supplies caused by radioactive wastes. I think it premature to say now positively that unsatisfactory conditions will not develop.

The Design of Supply Works

Dams

The questions of foundation grouting and uplift on masonry dams were discussed in the 1951 Report of this Committee. Since that time a sub-committee of the Power Division of ASCE has published its final report on uplift (43). This report contains considerable information and data which are worthy of careful study by those faced with this problem.

The matter of consolidation of earth in dams and other structures was covered extensively in our 1951 Report. Since that time the use of pneumatic equipment for compaction has increased because of savings in time and costs (44).

Tunnels

Roof supports of two types have been installed throughout most of the East Delaware tunnel of the Board of Water Supply, City of New York. At first the support comprised steel wall plates, ribs and lagging. Later a suspension type of support was adopted and used for most of the tunnel. It consisted of roof bolting extending into the rock, supporting steel roof ties on the face. A considerable reduction in rock excavation and concrete lining resulted from the development of the latter method. Other techniques used in constructing this 11 ft. 4 in. inside diameter tunnel are of interest (45) (46) (47).

Large Pipe Lines

The great increase in water consumption in many areas has stimulated the installation of an unusually large number of steel and concrete transmission mains during the past two-year period throughout various parts of the country, and many more are in the planning stage.

Among the recent large installations of steel pipe are those at Portland, Oregon, which consist of 26 miles of 56-inch and 66-inch pipe with coal tar enamel coating and lining, fabric exterior wrapping and Dresser coupled joints. The center half of the recently constructed 33-mile Bay Division Pipe Line No. 3 of the City of San Francisco is steel pipe with welded circumferential joints and protected by cement mortar coating and lining. Experiences of the East Bay Municipal District in use of cement-mortar linings and coatings of steel pipe are described by Kennedy (48). A recent paper by Cates (49) contains a comprehensive discussion of all types of coatings for steel pipe. Corrosion of steel pipe (and other steel structures) is recognized as a major problem, and there is continued increase in research studies and knowledge of methods of resisting it. A revision of Speller's comprehensive treatise on corrosion and methods of controlling it was published in 1951 (50). The use of cathodic protection for steel pipe lines and tanks has increased and has been covered in a number of recently published papers (51) (52) (53).

Recent articles of interest to the designer of large pipe lines include a discussion of analytical methods of determining the size and location of air valves by Parmakian (54) and discussions of water hammer problems by Kerr and others (55) (56).

A recent development in the manufacture of prestressed concrete pressure pipe with steel cylinder has been the forming of the core prior to prestressing by enclosing the cylinder in concrete and wrapping the wire on the concrete surface. Formerly the core was made by placing the concrete within the cylinder to form the core and wrapping the wire directly on the cylinder. The newer method is found to be more satisfactory for the larger sizes of prestressed pipe and has been used for pipe up to 72-inches in diameter. Practically all of the concrete water pipe installed in this country for internal pressures equivalent to a head of more than 100 feet has been the steel cylinder type.

Pumps and Pumping Stations

A new iron alloy containing magnesium, called ductile iron, has been successfully used recently for construction of pump casings and pipe (57). Its advantages are high strength, great resistance to bursting and ductility.

The 1951 Report of this Committee called attention to the increasing trend toward vertical submerged turbine pumps for intakes of water supply systems. This trend has continued and many of the recent installations are equipped with weatherproof motors and controls and are installed in the open at substantial savings in cost.

Descriptions of types of pumping installations and intakes suitable for supplies where surface levels are subject to great variations are covered in a recent paper by Fischer and Hartung (58).

Our 1951 Report mentioned the trend toward automatically operated pumping stations. The experience of the East Bay Municipal Utility District at Oakland, California in use of remote pump and valve control is described in a recent paper by Paul (59). Factors which should be considered in selecting pumping equipment are discussed in a paper by Niles (60).

Distribution Systems

General

Recent population growth and the tendency toward increase in per capita consumption of water during the dry periods of the past two years has resulted in unsatisfactory pressure conditions in many water systems and has shown the need for stronger distribution systems and additional storage. Large sums are being spent for these facilities and this trend will continue. Minimum standards for design, construction and maintenance of public water distribution systems have been established in Michigan (61) to aid small municipalities and developers to provide adequate systems.

Distribution System Pipe and Materials

Much progress has been made by the AWWA and others in the preparation of standard specifications for pipe and other materials for distribution systems in the past two-year period. The American Standards Association, sponsored by American Gas Association, American Society for Testing Materials, AWWA and New England Water Works Association have published the following specifications for cast iron pipe and fittings used in water works construction (62):

A21.2 Pit Cast Pipe
A21.4 Cement Mortar Lining
A21.6 Centrifugally Cast Pipe (Metal Molds)
A21.8 Centrifugally Cast Pipe (Sand-lined Molds)
A21.10 Short Body Fittings
A21.11 Mechanical Joint

AWWA specifications for hydrants (63) and cast iron pressure fittings (64) have been revised and specifications for asbestos cement water pipe have been prepared (65).

The use of plastic pipe for water services has been given considerable attention recently. Some success and some trouble have been experienced in its use. There is general hope that it will find a useful place in the water works field (66). Use on the West Coast has been described by Spaulding (67) and pipe characteristics, field experience elsewhere and status of test programs have been discussed by Socha, et al (68).

In 1951 the results of a partial investigation on disintegration and stress and strain on pipe joints made with sulphur compounds were published (69).

Studies of corrosion of cast iron pipe in Chicago and the durability of cement linings for cast iron pipe are discussed in two recent articles by Baylis (70) (71).

Storage Tanks

Many large steel and prestressed concrete storage tanks have been constructed. At Long Beach, California, in an earthquake area, steel tanks on the ground are claimed to be advantageous and have been extensively used (72).

During the past few years the East Bay Municipal District near San Francisco has constructed many prestressed concrete storage tanks from 250,000 gallons to 3-1/2 million gallons in capacity. At present the District has under construction the new Richmond Reservoir of 12 million gallons capacity which has a diameter of 204 feet and a height of 45 feet. It is said to be the largest structure of this kind constructed to date. A comprehensive article on the design of prestressed concrete tanks was published in 1952 (73).

The East Bay Municipal District at Oakland, California, is now engaged on a program of roofing its open surfaced reservoirs with precast columns, girders and slabs.

Asphaltic concrete is being used to reline Silver Lake, a large open storage reservoir in Los Angeles. Low cost is cited as a principal advantage in this method (74).

Design of Treatment Works

General

Relatively few new developments have occurred during the past two years in the design of water treatment facilities. However, considerable new construction has been initiated and completed. One of the most novel departures from conventional water works design has been the construction of a circular steel integral unit incorporating chemical mixing, coagulation, settling and filtration. Units have been in operation for two years at Alexandria, Virginia and new installations have been constructed at Chattanooga, Tennessee and Westmoreland County, Pennsylvania (75) (76). The design consists of a central mixing zone surrounded by peripheral flocculation, sedimentation and filtration units. The principal advantage claimed is in construction costs,

citing a cost of $65,000 per mgd for capacity for the 13.5 mgd plant in Alexandria compared to $100,000 to $300,000 per mgd for plants of conventional design and similar size. Other advantages claimed are low operating costs, flexibility, and ease of operation.

The United States Army Engineer Research and Development Laboratories at Fort Belvoir, Virginia, have developed a new 3,000 gal per hour mobile water purification unit (77) capable of purifying available surface water in temperatures ranging from -40° F. to 125° F. The heart of the unit is a solids contact clarifier, an all metal upflow coagulation basin, 7 feet in diameter and 5 feet high. The clarifier effluent is passed through diatomite filters. Hypochlorite is added for disinfection in the coagulating basin.

There has been a continuing interest in diatomite filters because of relatively low construction cost (78) but as yet there have been no sizeable installations.

Coagulation and Sedimentation

A review of recent research and experience in coagulation, published in The American City (79) considers coagulation delivering water with 10 ppm or more of suspended solids, including coagulated floc, to the filter as constituting unsatisfactory operation. The suitability and effectiveness of the treatment depend on (a) the type of coagulant used and (b) the design of the basin. Recent research at New York University found alum to be generally the best coagulant for intermediate and high water temperatures and for pH between 6.75 and 7.05, with iron salts generally the best for low water temperatures and for pH between 5.7 and 6.4.

A paper (133) by Langelier and co-workers at the University of California presented further explanations of the colloidal mechanics of flocculation, particularly with respect to the properties and size distribution of the suspended particles.

Experience at Kansas City, Kansas (80) indicated that cooling water from the electric plant improved the operation of flocculation and settling tanks in that it reduced ice formation and aided the formation of floc.

Activated silica continues in favor as an aid in toughening floc in cold water or under difficult conditions. Griffin (81) points out that activated silica can be formed by combining sodium silicate solution with chlorine, sulfuric acid or bicarbonate of soda. As the gel time varies with the raw water quality and may be from 15 minutes to 15 hours, careful laboratory tests should precede the silica use, and the best points of introduction should likewise be determined in advance.

Spaulding, Lowe and Schmitt (82) report excellent results in the use of pulverized limestone to increase alkalinity and improve coagulation and sedimentation, particularly in suspended solids contact basins.

In the design of sedimentation basins, area and overflow rate rather than detention time should probably govern (79). In attempting to establish standards for design, British practice is said to call for maximum of 600 gallons per day per square foot, when the water has a well formed floc, and 360 in less favorable conditions. A survey of 55 American plants shows a range from 88 to 2,340 gallons per day per square foot, with the average less than 800. There is some tendency toward 2-story basins, to provide relatively large areas and low overflow rates with economical construction and saving in land area. Examples listed are the Chicago South District, the Metropolitan Water District of Southern California, the Cleveland Nottingham Plant and the plant at Des Moines. An earlier example is the Milwaukee plant, and a recent

one is the new basin at the Dalecarlia plant in Washington. Two story basins are contemplated for the proposed Central District plant in Chicago.

Gridley (83) reports comparative operations of a solids contact or upward flow clarifier and a conventional type sedimentation basin at two small plants in West Virginia.

Softening

Incidental benefits achieved at Minneapolis by the lime-soda process (suspended solids contact basins) have been described by Janzig (84). The process is considered to be a purification aid in addition to its use in the reduction of hardness, as it assists in the removal of color, organic matter, algae, and bacteria of the coliform group. Used before filtration, it adds to the margin of protection where the source is a river having variable characteristics.

Caldwell and Lawrence (85) have described the construction and use of diagrams which greatly simplify equilibrium calculations as applied primarily to water softening and to scale and corrosion control. Use of the diagrams enables the determination of equilibrium concentrations of calcium, magnesium, total alkalinity and pH as related to the dosage of any of the commonly used conditioning chemicals.

Studies at St. Paul, Minn. on lime-soda softening at low temperatures have been reported by Thuma (86). During the five cold water months, hardness increases as the temperature recedes, until below 4^{o} C. the process fails to reduce the hardness of the water. Although the relationship between temperature and hardness reduction is not entirely consistent, possibly due to other varying influences such as variations in the character of the raw water, temperature plays a leading role in interference with the softening process. An attempt at split treatment, providing severe over-softening of a portion of the water, improved the general removal of hardness and the removal of color, but did not provide sufficient improvement to keep the hardness to a reasonable minimum in winter.

A new 2 mgd sodium zeolite water softening plant (87) has been constructed at Jacksonville Beach, Florida. A novel feature of the plant, although it is the third of its type in Florida, is the use of ocean water for regeneration and completely automatic control of operation including regeneration.

Pulaski, Virginia (88) has recently completed construction of a 3 mgd water softening and filtration plant. Some of the principal features of the plant are its coke tray aerators, and accelerator unit, carbonation units using oil fired CO_2 generators, and conventional sedimentation and filtration units.

A new use for water softener sludge was reported by automotive supply manufacturer in Plain City, Ohio (89). The waste sludge is used to treat metal plating wastes from their processing operations.

A recent investigation of sixteen municipal water treatment plants in Ohio (90) employing the recarbonation process emphasized the necessity of controlling the carbon monoxide hazard in certain types of installations. In one plant, the concentration of carbon monoxide on the main operating floor was hazardous. Improper fuel-air ratio in the burner, ill fitting manholes in the top of the recarbonation and lack of proper gas vent to the outside were primarily responsible for the dangerous condition.

Larson (91) (92) has presented a review of the comparative costs of municipal softening, home-owned softening, home-serviced softening, and soap used, as well as combined municipal and home softening. He concludes that

municipal softening to 85 ppm is advantageous, supplemented by home-owned or home-serviced softening where a "polished", completely soft water is desired. Economics of water softening also were discussed by Howson (93) with the conclusion that public water supplies having a hardness in excess of 125 ppm should be softened in a municipal softening plant, because softening can become economically and satisfactorily accomplished in the public water works than by the individual consumer.

Filter Plant Design

In the two-year period there have been no major developments in filter plant design. A number of interesting departures in design of details of rapid sand filters are described by Riddick (94). These include selection of sands for spherical characteristics and striate surface texture, filter bottoms made up perforated asbestos cement plates, wash water troughs placed higher than usual and butterfly type rate controllers.

An English development in water treatment called "Microstraining" has been under considerable investigation by American engineers. Microstrainers, or rotating drum filters with stainless steel cloth fabrics as the filtering media have been very successful in Great Britain as a pretreatment unit ahead of slow sand filters. They have been most successful in effecting removal of plankton - the fabric is extremely fine consisting of 75 pairs of warp wires (0.0024 inch diameter) per inch and 490 weft wires (0.0022 inch diameter) per inch. Some authorities (95) are skeptical as to the application of microstrainers in the United States because they cannot replace coagulation and sedimentation prior to rapid sand filtration. They may have application in reducing algae where algae are a seasonal problem and no other treatment is employed. Pilot plant experience (96) at Chicago South Filtration Plant indicates that microstrainers were capable of removing an average of 82 per cent of the plankton present in the raw water, but only 20 to 50 per cent of the turbidity. Other authorities (97) see a great future in the United States for microstrainers, particularly where algae are a problem. The total cost of an 8 mgd microstrainer installation in the midwest is estimated to be $75,000. Standard units are 7.5 feet in diameter and 5 feet long. They are reported to have a head loss of only 5 or 6 inches and use approximately 1 per cent of the water filtered for wash water.

At Lawrence, Kansas alternate filter units were equipped with sand and "Anthrafilt" to compare results. It is reported that the units with the coal media provided longer runs and used less wash water for equivalent conditions and results (98).

Dehumidification equipment has been installed at the South District Filtration Plant at Chicago. The installation has corrected excessive moisture conditions caused by condensation on walls and piping (99).

Taste and Odor Control

As stated in our 1951 Report, the single most important treatment for taste and odor control continues to be activated carbon, although free residual chlorine dioxide have been used in a number of plants.

Engineers at the Chicago South Filtration Plant have developed a method of slurry feeding of activated carbon to avoid serious dust problems otherwise encountered in the handling and dry feeding (100). The plant uses from 1,400 to 1,750 tons of activated carbon annually. The activated carbon is shipped in carload lots in hopper dump cars and the activated carbon is discharged

directly to the water storage tank through canvas chutes. The maximum slurry concentration that appears feasible is about 1.25 pounds of activated carbon per gallon of water. The activated carbon becomes wet in 3 to 5 days and may then be fed by a variable speed pump to achieve any required dosage. This system is said to be practically dust free and effects a significant saving of activated carbon.

The advantages of chlorine dioxide are well set forth in a review of experiences at several cities, published in The American City (101). It appears that this material is highly effective in overcoming taste and odor problems caused by phenols in small quantities, algae, organic matter, hydrocarbons, and other troublesome materials that resist other treatment, and that its advantages are becoming more generally recognized and its use more widespread.

Disinfection

In an effort to clarify the mechanism of the bactericidal action of chlorination, studies were made at the Georgia Institute of Technology (102) of the reactions of various chlorine compounds with the amino acids of proteins, and of the effect of certain chemicals in trying to reverse the action of chlorine on microorganisms. The data are said to explain in part the reason for the greater effectiveness of hypochlorous acid over monochloramine in water sterilization practice.

The use of dilute aqueous iodine as an emergency disinfectant for drinking water, in concentrations of 5 to 10 ppm, has been found by Chang and Morris (103) to be effective against all types of waterborne pathogenic organisms, including the enteric bacteria, amebic cysts, cercariae, leptospira and viruses, within ten minutes at room temperature and twenty minutes at lowest temperatures. High germicidal activity is maintained over the pH range 3 to 8 in the presence of a variety of water contaminants. Waters high in organic color may require increased dosage. The germicidal action of iodine is less dependent than are hypochlorites or chloramine type materials on pH, temperature, time of contact and nitrogenous impurities, and side reactions leading to consumption of the germicide are less marked.

Studies in Great Britain (104) indicated that the time of exposure to free chlorine and the time of exposure to and concentration of chloramines were the primary factors governing the extent of bacterial kill; that the killing power of free chlorine and chloramines diminished with increasing pH and rose with increasing temperatures; that when the effects of lowered temperature and high pH were combined, the reduction in bactericidal efficiency was very marked; that to obtain 100 per cent kill with the same exposure period required approximately 25 times as much chloramine as free chlorine; and that to obtain the same kill with the same amounts of chloramine and chlorine, the former required approximately 100 times the exposure period necessary for the latter.

The use of ultra-violet ray for sterilization of water has been found to be effective, but development of commercial equipment is necessary before it can be of general use for this purpose (105).

Fluoridation

The most active recent development in the water supply field has been the spectacular increase in the number of applications of fluoride to inhibit dental caries. In a report on a Census of Fluoridation in the United States and Canada,

1952, (106) a committee of the American Water Works Association presents statistics showing that, whereas in 1950, 62 water systems in 16 states employed fluoridation in supplies serving a population of 1,384,153, by the end of 1952 there were 354 systems in 43 states and the District of Columbia, serving a population of 12,590,292. In 1952, approximately 49 per cent of the plants serving 63 per cent of the population, used sodium silicofluoride with dry-feed equipment and approximately 41 per cent used sodium fluoride. Of the latter, about three-fifths used solution-feed units. Hydrofluosilicic acid was in use in nearly all of the remainder of the plants, with one plant each using hydrofluoric acid and ammonium silicofluoride.

Cities over 100,000 using fluoride by the end of 1952 included Little Rock, San Diego, San Francisco, Washington, Miami, Fort Wayne, Indianapolis, Louisville, Baltimore, Grand Rapids, St. Paul, New Rochelle, Rochester, Charlotte, Winston-Salem, Canton, Pittsburgh, Providence, Chattanooga, Corpus Christi, Norfolk, Richmond and Madison. Other major installations included DeKalb County in Georgia, the Washington Suburban Sanitary District and the Mahoning Sanitary District in Ohio.

Standards for minimum effective fluoride concentration are reported as 1.0 ppm in 30 states and the District of Columbia; 1.2 ppm in four states; 0.8 ppm in three states; 0.7 ppm in two states; and 0.6, 0.5, 0.5 to 1.5 and 0.4 to 1.0 in one state each. In only five states were no standards reported.

It was estimated that by May 15, 1953, the number of systems supplying fluoridated water had increased to 409 with a total population of 14,350,000, and that in addition 357 communities with a total population of 15,800,000 had approved fluoridation, but had not yet started it by that date. It thus appears that over 30 per cent of the urban population of the United States has or soon will have fluoridated water supply (107).

Although there is still considerable opposition from the viewpoint of certain of the food and beverage industries (108), and from others who feel that other vehicles or means of application would be more logical (109), the preponderence of present thinking and conclusions seems to favor the fluoridation of public water supplies as the most practicable method of reducing tooth decay.

Recent action by Canadian dental and medical groups favoring fluoridation has been reported (110), with fluoridation of community water supplies recommended by both the Canadian Public Health Association and the Ontario Dental Association for reduction of dental caries in areas with insufficient fluoride in the water and where the procedure can be controlled and supervised. A British Fluoridation Mission, following an investigation made in the United States (111), concluded that properly controlled fluoridation is effective, desirable and harmless, and that the fluoridation of water supplies is the preferable method of administrating fluorides.

After eight years of experience, Grand Rapids (112) reports reductions in decayed, missing and filled teeth of 66.6 per cent in 6-year old groups and 56 per cent in 5-year old groups. The 1952 results at Sheboygan, where fluoridation was started in 1946, indicated a maximum reduction of 58.5 per cent in children below the seventh grade, and a reduction of 29.7 per cent for children in the seventh and higher grades. In the sixth year of the survey in two New York cities (113), there has been a steadily diminishing incidence of dental caries in Newburgh, with fluoridation, and no significant change in the incidence at Kingston, the control city. Physical examinations including measurements of height and weight, laboratory tests and roentgen studies fail to disclose any significant deviations between the two groups.

An analysis of fluoridation costs was presented by Medbery (114) which indicated that the total cost of fluoridation is approximately 10 cents per capita per year for a city of 25,000 persons with the per capita cost decreasing with increasing population.

Water Analysis and Testing

The last Committee Report mentioned greater instrumentation in water laboratory determinations. Measurements of mass and volume are being supplanted or supplemented by measurements of interaction with radiant and electrical energy. The limitations, accuracy and expense of flame spectrometers, absorption photometric methods, potentiometric measurements and automatic analytical instruments are thoroughly covered in recent articles (115) (116).

Numerous developments have taken place in recent years in the field of water analysis. The membrane filter has been perfected and has found application in routine as well as special water analysis problems. The filter media, equipment, and technique of analysis have been extensively reviewed (117) (118) (119). The principal advantages of the membrane filter in water analysis are reported to be (a) reduction in the time required to conduct the test - 18 to 20 hours for coliform organisms, (b) accurate quantitative examination of coliforms, (c) less material, labor and space required than with the dilution method, and (d) particular applicability to studies of pathogenic organisms in water.

Recent fundamental studies (120) on the origin of tastes and odors in surface water supplies subject to industrial pollution have indicated that the principal taste and odor compounds present are neutral organic compounds and not organic acids or phenolic type substances. Taste and odor producing extracts that indicated a perceptible odor in odor free water in concentrations as low as 5 ppb have been isolated by means of carbon filters.

A statistical analysis (121) applied to a large number of microscopic counts of plankton in water supplies indicated that the error inherent in the counting procedure is considerably greater when the count is limited to 10 fields than the error ascribed to the sample preparation. A method was presented whereby the precision of counts may be estimated or the number of fields which must be counted to secure a given precision of analysis may be determined.

A unique device (122) has been employed by the Los Angeles Department of Water and Power in determining the temperature at various depths in reservoirs. The device called a "thermistor" employs a thermally sensitive resistor with a high negative temperature coefficient of resistance (4.4% per degree C.) which is considerably more sensitive than the commonly used fine platinum wire with a positive coefficient of resistivity (0.4% per degree C.). The device is reported to be simple and easy to operate.

Miscellaneous Developments

Among miscellaneous recent developments relating to water supply which continue to be of interest are desalting of sea water, cloud seeding to control rainfall, and the use of radioactive materials and fluorine for tracers.

Desalting Sea Water

Considerable attention has been given to the problem of producing fresh water from ocean or sea water. The use of ion exchange columns employing synthetic

zeolites and counterflow regeneration have been suggested (123) as a feasible method for converting moderately brackish waters (1500 to 2000 ppm dissolved solids) to fresh water (550 ppm or less). Ion exchange is claimed to be the most economical method of treatment of waters containing less than 2000 ppm dissolved solids. The cost is estimated to be 60 cents per 1000 gallons treated for each 1000 ppm of dissolved solids (as NaCl) removed.

Various authorities have reviewed the economies of fresh water recovery from sea water. One expert (124) concludes that of the possible methods solar distillation appears to be the most promising. Langelier (125) (126) has discussed the method of producing fresh water from sea water as announced by Ionics, Inc., of Cambridge, Massachusetts. The theory of electrochemical desalting of sea water employing ion exchange membranes was reviewed and a model unit for the process described.

A number of studies of methods for and economies of desalting sea water are in progress through research contracts financed by the federal government.

Rainmaking

There has been a continued interest in "cloud seeding" to control rainfall, but legal implications have been a discouraging factor in application of the method, particularly in the East. The work of the American Institute of Aerological Research and a general description of factors which must be considered in the successful application of cloud seeding were discussed by Krick (127) (128). He reviewed progress to date and predicted that within 10 years cloud seeding will be an indispensable tool to water users of all types. Using cloud seeding to check floods has been suggested by Vincent J. Schaefer, a pioneer of the method, but vastly more experimental work is needed before this can be accomplished (129).

New Tracer Materials

Both radioactive materials and fluorides have been used recently for tracers in water. Fox (130) has reported on using radioactive isotope to trace underground movements of water and Thomas (131) describes the utilization of such materials for ascertaining the flow pattern of water in tanks. Unquestionably many new and valuable water supply uses will be found for radioactive materials in the future.

An interesting use of fluorine in water in connection with a study of the hydraulic characteristics of the distribution system at Washington, D. C. is described by Levin and Jackson (132).

Federal Activities for Defense

The Federal Civil Defense Administration, through its Health and Special Weapons Defense Division and Engineering Services Division, has published recommendations for the emergency repair and maintenance of public water supplies (134) (135) (136), and has begun stockpiling of pipe and mobile purification equipment at strategic locations throughout the country. In collaboration with civil defense planning, the Office of Defense Mobilization, with the advice of the Facilities Protection Board, is considering measures leading toward development of an internal security program for the water works industry; also, the National Security Resources Board made preliminary investigations of the problems of water works in post-attack rehabilitation.

The Controlled Materials Plan, which was instituted by the NPA during the early phases of the Korean situation, was virtually terminated on June 30, 1953, thus allowing construction of water works and other civilian facilities without the necessity of securing allotments of materials for such projects.

In connection with the national security program, the Office of Defense Mobilization inaugurated in 1953 a program to determine the maximum mobilization of capability of the Nation's resources. In this program, consisting of an evaluation of basic manpower and material resources, various departments of the Federal Government were asked to submit estimates of mobilization requirements in terms of both dollar value and quantities of basic materials needed in their particular fields of interest and competency. For water works and sewerage, this responsibility has been assigned to the Public Health Service, Department of Health, Education, and Welfare.

Respectfully submitted,

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November 23, 1953

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of the Sanitary Engineering Division for the
Period Ending September 30, 1953

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WATER SUPPLY ENGINEERING

REPORT OF COMMITTEE ON WATER SUPPLY ENGINEERING OF THE SANITARY ENGINEERING DIVISION FOR THE PERIOD ENDING SEPTEMBER 30, 1953

The previous report of the Committee on Water Supply Engineering of the Sanitary Engineering Division was submitted at the Annual Meeting in October, 1951 and was published as Separate No. 164, Proceedings Vol. 79, January, 1953. Since that time Thomas H. Wiggin, M. ASCE and John R. Baylis, M. ASCE have resigned from the Committee. Each served on it many years and contributed much to the work of the Committee since it was established in 1933. The Committee wishes to express its appreciation of their generous contribution of time and effort to the work of the Committee since its inception. Since 1951 the following have been appointed as members of the Committee on Water Supply Engineering: Marshall P. Crabill, A.M. ASCE, Harvey F. Ludwig, A.M. ASCE, Thomas M. Niles, M. ASCE and Erman A. Pearson, A.M. ASCE.

The 1953 Report of the Committee covers trends, developments and events of interest to members of the water works profession, which have occurred during the period from October, 1951 to October, 1953.

Two of the trends which were noted in the 1951 Report have continued during the past two-year period. These are a general increase in per capita domestic water consumption and increased use of water for industrial purposes. These trends are believed to be the result of comparatively high levels of employment and income.

Another trend that has continued during the period is the increase in cost of water works operation, maintenance and construction. During the past few months this trend appears to be leveling off. It has resulted in many instances in the necessity of increasing water rates.

Although the period covered by this report has not witnessed any serious water shortages in municipal systems resulting from lack of supply, except in parts of the Southwest, peak water consumption during dry periods has caused low pressures and poor service in many communities. In general these conditions are caused by weak feeder mains and inadequate distribution storage facilities. The present tendency for increased construction of feeder mains and storage capacity must continue.

Rainfall during the period, except in the southwest and central parts of the country, has been comparatively normal. No unusual flood conditions have occurred.

The 1951 Report of this Committee described two different approaches to the problem of formulating a national water policy, or policies, one by the President's Water Policy Commission and the other by the Engineers' Joint Council (EJC). To date no action has been taken by the Administration or by Congress to adopt a definite water policy program. It has been suggested that a federal resources board be created to act as a coordinating agency and that the states and local interests should assume a larger share of the cost of water resources developments and in their initiation, planning, construction and operation. The recently appointed Committee for Reorganization of the Federal Government ("new Hoover Commission") will undoubtedly probe further into this subject.

The two-year period covered by this report has witnessed an exceptional

growth in the number of plants using fluoridation to reduce the development of dental caries. It has also been a period in which increased attention has been given to methods of controlling adverse effect of industrial wastes, including radioactive materials, on water supplies. These developments, and other recent items of interest in connection with sources of supply works, distribution systems, treatment works, and water analysis and testing, are described in the report.

Since the creation of the Federal Civil Defense Administration in 1951 the role of water works in civil defense has received increased attention. Technical Manual 13-2, "Operation and Repair of Water Facilities in Civil Defense Emergencies", published by the FCDA in September, 1953, recommends procedures for maintaining the quantity and safety of water supplies in communities subjected to attack by conventional and unconventional weapons including atomic, radiological, chemical, and biological warfare.

Sources of Water Supply

Ground Water

Continuation of drought conditions in the Southwest during the past two-year period has caused serious depletion of ground water supplies and intrusion of sea water in certain areas. This has given impetus to studies of recharging of underground storage and of the effects of sea water intrusion on ground water supplies.

The State of California has continued its comprehensive statewide investigation known as the "California Water Plan" which was mentioned in our 1951 report. Bulletin No. 1, "Water Resources of California" was published in July, 1951. It contains much information on ground water conditions. Additional studies through cooperative contracts with the United States Geological Survey of ground water levels, measurement of stream bed percolation and extent of present use of ground water are underway.

In 1951 the State of California appropriated $750,000 to its Water Resources Board for investigational work and study of methods and design criteria for the prevention of sea water intrusion into ground water basins. The project includes construction and testing of a number of injection wells of various types. Much more experimental work is necessary before conclusive results are attained (1).

A number of recent papers describe various methods for recharge and utilization of excess stream flows, sewage and industrial waste for augmenting underground water supplies (2) (3) (4) (5).

Ground water conditions in general throughout the past two-year period have been normal except for the southwest part of the country. This is shown by data in the monthly issues of Water Resources Review of the United States Geological Survey (USGS). As stated in the 1951 Report of this Committee, a very complete discussion of ground water supplies and conditions in the United States is contained in Geological Survey Paper No. 114 (6). An excellent general treatise on ground water which describes its use and misuse was published in 1951 (7).

Miscellaneous subjects of interest in connection with ground water supplies covered by recently published articles include descriptions of seismic and electrical methods for exploring underground conditions (8), use of explosives for improving wells (9), and installation and performance of radial collector wells (10).

Surface Water

Circular No. 15 of the United States Geological Survey contains interesting

statistical estimates of water consumption in the United States in 1950. Industrial use from private industrial supplies was estimated to be 77,000 mgd. Consumption of municipal water systems (public and private) was estimated to be 13,640 mgd, or an average of 145 gcd for 93-1/2 million consumers. Of the latter amount, 10,056 mgd were obtained from surface waters and 3,584 mgd from ground water supplies (11). These estimates, compared to previously published similar estimates and records of water consumption in various parts of the country, show two interesting trends: (a) a definite substantial increase in per capita water consumption, and (b) a much greater use of water by industry.

The needs and problems relating to industrial use of water are being studied by an American Water Works Association (AWWA) task group (12) and have been discussed by others within the past two-year period (13) (14).

Preliminary plans and estimates were presented in a report of the State Engineer of California in 1951 on the Feather River Project and surveys and preliminary designs are now underway. The project comprises a dam 710 feet high on the Feather River in northern California to form a storage reservoir of 3-1/2 million acre-feet from which water would be diverted by means of a system of tunnels, pumping and canals to supply the Feather River service area, Southern Alameda and Santa Clara Counties in the San Francisco area, the southern part of San Joaquin Valley and portions of Southern California south of the Tehachapi Mountains. The estimated cost of this large water supply project is about 1-1/2 billion dollars (15). A similar project for supplying dry areas in Southern California by means of a dam at the mouth of the Klamath River, diversion to the Sacramento River and successive pumping stations, canals and tunnels extending as far south as San Diego, has been considered. The estimated cost of this immense water supply project is $3-1/2 billion (16).

In the 1951 Report of this Committee, the 1949-50 shortage of water supply for New York City and plans for increasing the supply by 540 mgd by the first two stages of the Delaware-Roundout supply were discussed. Stage 1 of this project is in partial use and Stage 2 will be in use within the next two years (17). Inasmuch as development of the "Incodel" plan (18) for diverting upper Delaware River water to northeastern New Jersey and New York City was opposed by Pennsylvania (19), and a proposed plan for using the waters of the Hudson River was disapproved by the Board of Estimate (20) New York City is now planning a third stage of its Delaware River supply. It has applied to the Supreme Court of the United States to permit an increase in diversion from the Delaware River from 440 to 800 mgd by diverting water from the West Branch of the river at Cannonsville through a 25-mile tunnel to the Pepacton Reservoir now under construction on the East Branch of the Delaware. A Special Master was appointed to hear the case. After extensive testimony by the parties involved, an agreement was reached by them to recommend to the Special Master a method for division of the yield of the river (21). Up to the first of October, 1953, no report has been made by the Special Master. Unless there is a change in the attitude of Pennsylvania in favor of a tri-state project, it will be necessary for individual action of New Jersey and New York to develop additional supplies which are needed now by New Jersey and will be needed in a few years by New York City.

Additional surface water supplies under construction in the San Francisco area include the Big Carson Dam of the Marin Municipal Water District on the northwest side of San Francisco Bay and the Cherry Valley Dam which will be utilized for power, flood control, irrigation and for increasing the municipal supply of San Francisco.

The increase in use of water in various parts of the United States has stimulated plans for development of many additional surface water supplies.

Effect of Dry Periods

Drought conditions during the past two years throughout the Southwest have caused extensive agricultural damage and have resulted in the necessity of curtailing municipal and industrial water use. Record breaking hot and dry periods at Dallas in 1952 forced a reduction of water consumption of about 40 per cent (22). Dry periods of short duration were experienced in the early summer of 1952 and the late summer of 1953 in the central and eastern parts of the United States. These resulted in peak consumption which caused poor service and low pressures. In most cases this was because of inadequacies of distribution system facilities rather than depletion of sources of supply.

Effect of Wet Periods and Floods

In 1952 prolonged high water levels in the Great Lakes caused concern. Record monthly highs were reported in February for Lake Superior and in May and June for Lakes Erie and Ontario. On September 11, 1952, an extraordinary peak flow of 450,000 cfs from 947 square miles, or 474 cfs per square mile, was recorded on the Pedernales River near Johnson City, Texas. The same storm caused a high flow of 152.6 cfs per square mile from a drainage area of 5,500 square miles on the Colorado River at Lake Travis, Texas. Otherwise, there were no unusual flood conditions during 1952 and 1953 to date (23).

In our Report of 1951, reference was made to the disastrous flood of July, 1951 in the Kansas River Basin. Flood control plans comprising large storage reservoirs were proposed by the United States Bureau of Reclamation and the United States Corps of Reclamation and the United States Corps of Engineers prior to the 1951 flood and were recommended by the United States Corps of Engineers subsequent to the flood. A Board of Engineers engaged in 1952 by the Kansas Industrial Development Commission submitted a final report in June, 1953 in which they recommended as a substitute for the large storage reservoir plan, a plan of local protection works comprising channels, flow-ways and dikes designed to carry flows in excess of the 1951 flood. The Board claimed that this plan would be much cheaper and more effective than the large storage reservoir plan (24).

Efforts have been made to develop an overall body to supervise operation of completed projects and plans for future developments in the Missouri River Basin. In January, 1953, the Council of State Governments prepared for the Missouri River States Committee a revised draft of a Missouri River Compact which would provide for participation by the ten states of the region and by the federal government in the formulation of basic broad policy. It also proposed to utilize established governmental agencies for construction of facilities and in the operations of programs (25). These proposals are under consideration.

Erosion Control and Reservoir Silting

As stated in the 1951 Report of this Committee, the loss in storage capacity of reservoirs resulting from land erosion is substantial. A task group of AWWA has this subject under investigation and study. It submitted a preliminary report with an extensive bibliography in August, 1953 (26).

Sounding methods for sedimentation studies, including supersonic methods using echo sounders and direct measurement of sediment thickness, are described in a recent ASCE symposium (27).

Progress in Municipal Pollution Control

Progress in municipal pollution abatement during 1952, measured in dollar volume, was the lowest on record since 1948. (PHS Pub. 291, Public Sewage Treatment Plant Construction, 1952). The volume for the first half of 1953 was 39 percent higher than the corresponding period of 1952, indicating perhaps a reflection of greater material availability as the Nation moved toward completion of its defense buildup. Interest rates for municipal construction increased during the 2-year period from about 2 percent to slightly above 3 percent, but again turned downward during the Summer of 1953. (The Bond Buyer, October 17, 1953, Vol. 127, No. 9, Section II, p. 1, The Bond Buyer's Index --20 Municipals).

Progress in Industrial Pollution Control

There has been much progress in investigations and studies in industrial pollution control facilities during the past two-year period. Important new studies were the results of grants under the Federal Water Pollution Control Act for industrial waste investigations. Many new industrial establishments have incorporated extensive pollution control plants in the initial plant installation. Examples of these are the treatment plants of the United States Steel Corporation at Morrisville, Pennsylvania (28) and of the Link-Belt Company at Lansdale, Pennsylvania (29). No satisfactory method for determining actual progress by United States industry in the abatement of industrial pollution, comparable to the means available for measuring municipal pollution abatement has yet been developed.

The current work of the United States Public Health Service (USPHS) in conjunction with state agencies, the National Council for Stream Improvement, the Ohio River Commission, and the programs of New York, California and Pennsylvania in connection with pollution abatement were discussed in our 1951 Report. Considerable progress has been made during the past two-year period by these and other agencies in establishing general policies and in carrying out surveys, investigations and promoting actual design and construction.

The three-year report of the California Water Pollution Control Board on work accomplished since the passage of the 1949 Pollution Control Act provides an interesting and encouraging account of its activities in fact-finding, research and coordination (30). This Board also has published a comprehensive research report on water quality criteria (31).

The Ohio River Valley Water Sanitation Commission has recommended tax aid through early write-off of industrial waste pollution abatement (32). A survey of 1,939 industrial plants in the New England area by the New England Interstate Water Pollution Control Commission indicated an equivalent pollution load of 5 million people in the area with only 6.6 per cent of the industrial waste being treated (33).

Within the past two-year period there have been extensive investigations on methods for testing water for radioactive materials, the effect of radioactive materials on water supply systems and of methods of removing them. Equipment and methods for detecting radioactive materials in water are described in references (34) (35) (36). The significance and effect of radioactive wastes are covered in a number of recently published papers (37) (38) (39) (40). Standard settling and filtration methods of water treatment and biological methods of sewage treatment have been shown to be effective in removal of certain types of radioactive materials. In some instances special treatment

using powdered metal and other substances have been effective (41) (42). A review of the extensive literature describing research work and tests which have been accomplished and are under way provides assurance that cooperative efforts of the Atomic Energy Commission, research scientists and those in responsible charge of water supply systems can prevent the development of unsatisfactory conditions in public water supplies caused by radioactive wastes. I think it premature to say now positively that unsatisfactory conditions will not develop.

The Design of Supply Works

Dams

The questions of foundation grouting and uplift on masonry dams were discussed in the 1951 Report of this Committee. Since that time a sub-committee of the Power Division of ASCE has published its final report on uplift (43). This report contains considerable information and data which are worthy of careful study by those faced with this problem.

The matter of consolidation of earth in dams and other structures was covered extensively in our 1951 Report. Since that time the use of pneumatic equipment for compaction has increased because of savings in time and costs (44).

Tunnels

Roof supports of two types have been installed throughout most of the East Delaware tunnel of the Board of Water Supply, City of New York. At first the support comprised steel wall plates, ribs and lagging. Later a suspension type of support was adopted and used for most of the tunnel. It consisted of roof bolting extending into the rock, supporting steel roof ties on the face. A considerable reduction in rock excavation and concrete lining resulted from the development of the latter method. Other techniques used in constructing this 11 ft. 4 in. inside diameter tunnel are of interest (45) (46) (47).

Large Pipe Lines

The great increase in water consumption in many areas has stimulated the installation of an unusually large number of steel and concrete transmission mains during the past two-year period throughout various parts of the country, and many more are in the planning stage.

Among the recent large installations of steel pipe are those at Portland, Oregon, which consist of 26 miles of 56-inch and 66-inch pipe with coal tar enamel coating and lining, fabric exterior wrapping and Dresser coupled joints. The center half of the recently constructed 33-mile Bay Division Pipe Line No. 3 of the City of San Francisco is steel pipe with welded circumferential joints and protected by cement mortar coating and lining. Experiences of the East Bay Municipal District in use of cement-mortar linings and coatings of steel pipe are described by Kennedy (48). A recent paper by Cates (49) contains a comprehensive discussion of all types of coatings for steel pipe. Corrosion of steel pipe (and other steel structures) is recognized as a major problem, and there is continued increase in research studies and knowledge of methods of resisting it. A revision of Speller's comprehensive treatise on corrosion and methods of controlling it was published in 1951 (50). The use of cathodic protection for steel pipe lines and tanks has increased and has been covered in a number of recently published papers (51) (52) (53).

Recent articles of interest to the designer of large pipe lines include a discussion of analytical methods of determining the size and location of air valves by Parmakian (54) and discussions of water hammer problems by Kerr and others (55) (56).

A recent development in the manufacture of prestressed concrete pressure pipe with steel cylinder has been the forming of the core prior to prestressing by enclosing the cylinder in concrete and wrapping the wire on the concrete surface. Formerly the core was made by placing the concrete within the cylinder to form the core and wrapping the wire directly on the cylinder. The newer method is found to be more satisfactory for the larger sizes of prestressed pipe and has been used for pipe up to 72-inches in diameter. Practically all of the concrete water pipe installed in this country for internal pressures equivalent to a head of more than 100 feet has been the steel cylinder type.

Pumps and Pumping Stations

A new iron alloy containing magnesium, called ductile iron, has been successfully used recently for construction of pump casings and pipe (57). Its advantages are high strength, great resistance to bursting and ductility.

The 1951 Report of this Committee called attention to the increasing trend toward vertical submerged turbine pumps for intakes of water supply systems. This trend has continued and many of the recent installations are equipped with weatherproof motors and controls and are installed in the open at substantial savings in cost.

Descriptions of types of pumping installations and intakes suitable for supplies where surface levels are subject to great variations are covered in a recent paper by Fischer and Hartung (58).

Our 1951 Report mentioned the trend toward automatically operated pumping stations. The experience of the East Bay Municipal Utility District at Oakland, California in use of remote pump and valve control is described in a recent paper by Paul (59). Factors which should be considered in selecting pumping equipment are discussed in a paper by Niles (60).

Distribution Systems

General

Recent population growth and the tendency toward increase in per capita consumption of water during the dry periods of the past two years has resulted in unsatisfactory pressure conditions in many water systems and has shown the need for stronger distribution systems and additional storage. Large sums are being spent for these facilities and this trend will continue. Minimum standards for design, construction and maintenance of public water distribution systems have been established in Michigan (61) to aid small municipalities and developers to provide adequate systems.

Distribution System Pipe and Materials

Much progress has been made by the AWWA and others in the preparation of standard specifications for pipe and other materials for distribution systems in the past two-year period. The American Standards Association, sponsored by American Gas Association, American Society for Testing Materials, AWWA and New England Water Works Association have published the following specifications for cast iron pipe and fittings used in water works construction (62):

A21.2 Pit Cast Pipe
A21.4 Cement Mortar Lining
A21.6 Centrifugally Cast Pipe (Metal Molds)
A21.8 Centrifugally Cast Pipe (Sand-lined Molds)
A21.10 Short Body Fittings
A21.11 Mechanical Joint

AWWA specifications for hydrants (63) and cast iron pressure fittings (64) have been revised and specifications for asbestos cement water pipe have been prepared (65).

The use of plastic pipe for water services has been given considerable attention recently. Some success and some trouble have been experienced in its use. There is general hope that it will find a useful place in the water works field (66). Use on the West Coast has been described by Spaulding (67) and pipe characteristics, field experience elsewhere and status of test programs have been discussed by Socha, et al (68).

In 1951 the results of a partial investigation on disintegration and stress and strain on pipe joints made with sulphur compounds were published (69).

Studies of corrosion of cast iron pipe in Chicago and the durability of cement linings for cast iron pipe are discussed in two recent articles by Baylis (70) (71).

Storage Tanks

Many large steel and prestressed concrete storage tanks have been constructed. At Long Beach, California, in an earthquake area, steel tanks on the ground are claimed to be advantageous and have been extensively used (72).

During the past few years the East Bay Municipal District near San Francisco has constructed many prestressed concrete storage tanks from 250,000 gallons to 3-1/2 million gallons in capacity. At present the District has under construction the new Richmond Reservoir of 12 million gallons capacity which has a diameter of 204 feet and a height of 45 feet. It is said to be the largest structure of this kind constructed to date. A comprehensive article on the design of prestressed concrete tanks was published in 1952 (73).

The East Bay Municipal District at Oakland, California, is now engaged on a program of roofing its open surfaced reservoirs with precast columns, girders and slabs.

Asphaltic concrete is being used to reline Silver Lake, a large open storage reservoir in Los Angeles. Low cost is cited as a principal advantage in this method (74).

Design of Treatment Works

General

Relatively few new developments have occurred during the past two years in the design of water treatment facilities. However, considerable new construction has been initiated and completed. One of the most novel departures from conventional water works design has been the construction of a circular steel integral unit incorporating chemical mixing, coagulation, settling and filtration. Units have been in operation for two years at Alexandria, Virginia and new installations have been constructed at Chattanooga, Tennessee and Westmoreland County, Pennsylvania (75) (76). The design consists of a central mixing zone surrounded by peripheral flocculation, sedimentation and filtration units. The principal advantage claimed is in construction costs,

citing a cost of $65,000 per mgd for capacity for the 13.5 mgd plant in Alexandria compared to $100,000 to $300,000 per mgd for plants of conventional design and similar size. Other advantages claimed are low operating costs, flexibility, and ease of operation.

The United States Army Engineer Research and Development Laboratories at Fort Belvoir, Virginia, have developed a new 3,000 gal per hour mobile water purification unit (77) capable of purifying available surface water in temperatures ranging from -40° F. to 125° F. The heart of the unit is a solids contact clarifier, an all metal upflow coagulation basin, 7 feet in diameter and 5 feet high. The clarifier effluent is passed through diatomite filters. Hypochlorite is added for disinfection in the coagulating basin.

There has been a continuing interest in diatomite filters because of relatively low construction cost (78) but as yet there have been no sizeable installations.

Coagulation and Sedimentation

A review of recent research and experience in coagulation, published in The American City (79) considers coagulation delivering water with 10 ppm or more of suspended solids, including coagulated floc, to the filter as constituting unsatisfactory operation. The suitability and effectiveness of the treatment depend on (a) the type of coagulant used and (b) the design of the basin. Recent research at New York University found alum to be generally the best coagulant for intermediate and high water temperatures and for pH between 6.75 and 7.05, with iron salts generally the best for low water temperatures and for pH between 5.7 and 6.4.

A paper (133) by Langelier and co-workers at the University of California presented further explanations of the colloidal mechanics of flocculation, particularly with respect to the properties and size distribution of the suspended particles.

Experience at Kansas City, Kansas (80) indicated that cooling water from the electric plant improved the operation of flocculation and settling tanks in that it reduced ice formation and aided the formation of floc.

Activated silica continues in favor as an aid in toughening floc in cold water or under difficult conditions. Griffin (81) points out that activated silica can be formed by combining sodium silicate solution with chlorine, sulfuric acid or bicarbonate of soda. As the gel time varies with the raw water quality and may be from 15 minutes to 15 hours, careful laboratory tests should precede the silica use, and the best points of introduction should likewise be determined in advance.

Spaulding, Lowe and Schmitt (82) report excellent results in the use of pulverized limestone to increase alkalinity and improve coagulation and sedimentation, particularly in suspended solids contact basins.

In the design of sedimentation basins, area and overflow rate rather than detention time should probably govern (79). In attempting to establish standards for design, British practice is said to call for maximum of 600 gallons per day per square foot, when the water has a well formed floc, and 360 in less favorable conditions. A survey of 55 American plants shows a range from 88 to 2,340 gallons per day per square foot, with the average less than 800. There is some tendency toward 2-story basins, to provide relatively large areas and low overflow rates with economical construction and saving in land area. Examples listed are the Chicago South District, the Metropolitan Water District of Southern California, the Cleveland Nottingham Plant and the plant at Des Moines. An earlier example is the Milwaukee plant, and a recent

one is the new basin at the Dalecarlia plant in Washington. Two story basins are contemplated for the proposed Central District plant in Chicago.

Gridley (83) reports comparative operations of a solids contact or upward flow clarifier and a conventional type sedimentation basin at two small plants in West Virginia.

Softening

Incidental benefits achieved at Minneapolis by the lime-soda process (suspended solids contact basins) have been described by Janzig (84). The process is considered to be a purification aid in addition to its use in the reduction of hardness, as it assists in the removal of color, organic matter, algae, and bacteria of the coliform group. Used before filtration, it adds to the margin of protection where the source is a river having variable characteristics.

Caldwell and Lawrence (85) have described the construction and use of diagrams which greatly simplify equilibrium calculations as applied primarily to water softening and to scale and corrosion control. Use of the diagrams enables the determination of equilibrium concentrations of calcium, magnesium, total alkalinity and pH as related to the dosage of any of the commonly used conditioning chemicals.

Studies at St. Paul, Minn. on lime-soda softening at low temperatures have been reported by Thuma (86). During the five cold water months, hardness increases as the temperature recedes, until below 4^{o} C. the process fails to reduce the hardness of the water. Although the relationship between temperature and hardness reduction is not entirely consistent, possibly due to other varying influences such as variations in the character of the raw water, temperature plays a leading role in interference with the softening process. An attempt at split treatment, providing severe over-softening of a portion of the water, improved the general removal of hardness and the removal of color, but did not provide sufficient improvement to keep the hardness to a reasonable minimum in winter.

A new 2 mgd sodium zeolite water softening plant (87) has been constructed at Jacksonville Beach, Florida. A novel feature of the plant, although it is the third of its type in Florida, is the use of ocean water for regeneration and completely automatic control of operation including regeneration.

Pulaski, Virginia (88) has recently completed construction of a 3 mgd water softening and filtration plant. Some of the principal features of the plant are its coke tray aerators, and accelerator unit, carbonation units using oil fired CO_2 generators, and conventional sedimentation and filtration units.

A new use for water softener sludge was reported by automotive supply manufacturer in Plain City, Ohio (89). The waste sludge is used to treat metal plating wastes from their processing operations.

A recent investigation of sixteen municipal water treatment plants in Ohio (90) employing the recarbonation process emphasized the necessity of controlling the carbon monoxide hazard in certain types of installations. In one plant, the concentration of carbon monoxide on the main operating floor was hazardous. Improper fuel-air ratio in the burner, ill fitting manholes in the top of the recarbonation and lack of proper gas vent to the outside were primarily responsible for the dangerous condition.

Larson (91) (92) has presented a review of the comparative costs of municipal softening, home-owned softening, home-serviced softening, and soap used, as well as combined municipal and home softening. He concludes that

municipal softening to 85 ppm is advantageous, supplemented by home-owned or home-serviced softening where a "polished", completely soft water is desired. Economics of water softening also were discussed by Howson (93) with the conclusion that public water supplies having a hardness in excess of 125 ppm should be softened in a municipal softening plant, because softening can become economically and satisfactorily accomplished in the public water works than by the individual consumer.

Filter Plant Design

In the two-year period there have been no major developments in filter plant design. A number of interesting departures in design of details of rapid sand filters are described by Riddick (94). These include selection of sands for spherical characteristics and striate surface texture, filter bottoms made up perforated asbestos cement plates, wash water troughs placed higher than usual and butterfly type rate controllers.

An English development in water treatment called "Microstraining" has been under considerable investigation by American engineers. Microstrainers, or rotating drum filters with stainless steel cloth fabrics as the filtering media have been very successful in Great Britain as a pretreatment unit ahead of slow sand filters. They have been most successful in effecting removal of plankton - the fabric is extremely fine consisting of 75 pairs of warp wires (0.0024 inch diameter) per inch and 490 weft wires (0.0022 inch diameter) per inch. Some authorities (95) are skeptical as to the application of microstrainers in the United States because they cannot replace coagulation and sedimentation prior to rapid sand filtration. They may have application in reducing algae where algae are a seasonal problem and no other treatment is employed. Pilot plant experience (96) at Chicago South Filtration Plant indicates that microstrainers were capable of removing an average of 82 per cent of the plankton present in the raw water, but only 20 to 50 per cent of the turbidity. Other authorities (97) see a great future in the United States for microstrainers, particularly where algae are a problem. The total cost of an 8 mgd microstrainer installation in the midwest is estimated to be $75,000. Standard units are 7.5 feet in diameter and 5 feet long. They are reported to have a head loss of only 5 or 6 inches and use approximately 1 per cent of the water filtered for wash water.

At Lawrence, Kansas alternate filter units were equipped with sand and "Anthrafilt" to compare results. It is reported that the units with the coal media provided longer runs and used less wash water for equivalent conditions and results (98).

Dehumidification equipment has been installed at the South District Filtration Plant at Chicago. The installation has corrected excessive moisture conditions caused by condensation on walls and piping (99).

Taste and Odor Control

As stated in our 1951 Report, the single most important treatment for taste and odor control continues to be activated carbon, although free residual chlorine dioxide have been used in a number of plants.

Engineers at the Chicago South Filtration Plant have developed a method of slurry feeding of activated carbon to avoid serious dust problems otherwise encountered in the handling and dry feeding (100). The plant uses from 1,400 to 1,750 tons of activated carbon annually. The activated carbon is shipped in carload lots in hopper dump cars and the activated carbon is discharged

directly to the water storage tank through canvas chutes. The maximum slurry concentration that appears feasible is about 1.25 pounds of activated carbon per gallon of water. The activated carbon becomes wet in 3 to 5 days and may then be fed by a variable speed pump to achieve any required dosage. This system is said to be practically dust free and effects a significant saving of activated carbon.

The advantages of chlorine dioxide are well set forth in a review of experiences at several cities, published in The American City (101). It appears that this material is highly effective in overcoming taste and odor problems caused by phenols in small quantities, algae, organic matter, hydrocarbons, and other troublesome materials that resist other treatment, and that its advantages are becoming more generally recognized and its use more widespread.

Disinfection

In an effort to clarify the mechanism of the bactericidal action of chlorination, studies were made at the Georgia Institute of Technology (102) of the reactions of various chlorine compounds with the amino acids of proteins, and of the effect of certain chemicals in trying to reverse the action of chlorine on microorganisms. The data are said to explain in part the reason for the greater effectiveness of hypochlorous acid over monochloramine in water sterilization practice.

The use of dilute aqueous iodine as an emergency disinfectant for drinking water, in concentrations of 5 to 10 ppm, has been found by Chang and Morris (103) to be effective against all types of waterborne pathogenic organisms, including the enteric bacteria, amebic cysts, cercariae, leptospira and viruses, within ten minutes at room temperature and twenty minutes at lowest temperatures. High germicidal activity is maintained over the pH range 3 to 8 in the presence of a variety of water contaminants. Waters high in organic color may require increased dosage. The germicidal action of iodine is less dependent than are hypochlorites or chloramine type materials on pH, temperature, time of contact and nitrogenous impurities, and side reactions leading to consumption of the germicide are less marked.

Studies in Great Britain (104) indicated that the time of exposure to free chlorine and the time of exposure to and concentration of chloramines were the primary factors governing the extent of bacterial kill; that the killing power of free chlorine and chloramines diminished with increasing pH and rose with increasing temperatures; that when the effects of lowered temperature and high pH were combined, the reduction in bactericidal efficiency was very marked; that to obtain 100 per cent kill with the same exposure period required approximately 25 times as much chloramine as free chlorine; and that to obtain the same kill with the same amounts of chloramine and chlorine, the former required approximately 100 times the exposure period necessary for the latter.

The use of ultra-violet ray for sterilization of water has been found to be effective, but development of commercial equipment is necessary before it can be of general use for this purpose (105).

Fluoridation

The most active recent development in the water supply field has been the spectacular increase in the number of applications of fluoride to inhibit dental caries. In a report on a Census of Fluoridation in the United States and Canada,

1952, (106) a committee of the American Water Works Association presents statistics showing that, whereas in 1950, 62 water systems in 16 states employed fluoridation in supplies serving a population of 1,384,153, by the end of 1952 there were 354 systems in 43 states and the District of Columbia, serving a population of 12,590,292. In 1952, approximately 49 per cent of the plants serving 63 per cent of the population, used sodium silicofluoride with dry-feed equipment and approximately 41 per cent used sodium fluoride. Of the latter, about three-fifths used solution-feed units. Hydrofluosilicic acid was in use in nearly all of the remainder of the plants, with one plant each using hydrofluoric acid and ammonium silicofluoride.

Cities over 100,000 using fluoride by the end of 1952 included Little Rock, San Diego, San Francisco, Washington, Miami, Fort Wayne, Indianapolis, Louisville, Baltimore, Grand Rapids, St. Paul, New Rochelle, Rochester, Charlotte, Winston-Salem, Canton, Pittsburgh, Providence, Chattanooga, Corpus Christi, Norfolk, Richmond and Madison. Other major installations included DeKalb County in Georgia, the Washington Suburban Sanitary District and the Mahoning Sanitary District in Ohio.

Standards for minimum effective fluoride concentration are reported as 1.0 ppm in 30 states and the District of Columbia; 1.2 ppm in four states; 0.8 ppm in three states; 0.7 ppm in two states; and 0.6, 0.5, 0.5 to 1.5 and 0.4 to 1.0 in one state each. In only five states were no standards reported.

It was estimated that by May 15, 1953, the number of systems supplying fluoridated water had increased to 409 with a total population of 14,350,000, and that in addition 357 communities with a total population of 15,800,000 had approved fluoridation, but had not yet started it by that date. It thus appears that over 30 per cent of the urban population of the United States has or soon will have fluoridated water supply (107).

Although there is still considerable opposition from the viewpoint of certain of the food and beverage industries (108), and from others who feel that other vehicles or means of application would be more logical (109), the preponderence of present thinking and conclusions seems to favor the fluoridation of public water supplies as the most practicable method of reducing tooth decay.

Recent action by Canadian dental and medical groups favoring fluoridation has been reported (110), with fluoridation of community water supplies recommended by both the Canadian Public Health Association and the Ontario Dental Association for reduction of dental caries in areas with insufficient fluoride in the water and where the procedure can be controlled and supervised. A British Fluoridation Mission, following an investigation made in the United States (111), concluded that properly controlled fluoridation is effective, desirable and harmless, and that the fluoridation of water supplies is the preferable method of administrating fluorides.

After eight years of experience, Grand Rapids (112) reports reductions in decayed, missing and filled teeth of 66.6 per cent in 6-year old groups and 56 per cent in 5-year old groups. The 1952 results at Sheboygan, where fluoridation was started in 1946, indicated a maximum reduction of 58.5 per cent in children below the seventh grade, and a reduction of 29.7 per cent for children in the seventh and higher grades. In the sixth year of the survey in two New York cities (113), there has been a steadily diminishing incidence of dental caries in Newburgh, with fluoridation, and no significant change in the incidence at Kingston, the control city. Physical examinations including measurements of height and weight, laboratory tests and roentgen studies fail to disclose any significant deviations between the two groups.

An analysis of fluoridation costs was presented by Medbery (114) which indicated that the total cost of fluoridation is approximately 10 cents per capita per year for a city of 25,000 persons with the per capita cost decreasing with increasing population.

Water Analysis and Testing

The last Committee Report mentioned greater instrumentation in water laboratory determinations. Measurements of mass and volume are being supplanted or supplemented by measurements of interaction with radiant and electrical energy. The limitations, accuracy and expense of flame spectrometers, absorption photometric methods, potentiometric measurements and automatic analytical instruments are thoroughly covered in recent articles (115) (116).

Numerous developments have taken place in recent years in the field of water analysis. The membrane filter has been perfected and has found application in routine as well as special water analysis problems. The filter media, equipment, and technique of analysis have been extensively reviewed (117) (118) (119). The principal advantages of the membrane filter in water analysis are reported to be (a) reduction in the time required to conduct the test - 18 to 20 hours for coliform organisms, (b) accurate quantitative examination of coliforms, (c) less material, labor and space required than with the dilution method, and (d) particular applicability to studies of pathogenic organisms in water.

Recent fundamental studies (120) on the origin of tastes and odors in surface water supplies subject to industrial pollution have indicated that the principal taste and odor compounds present are neutral organic compounds and not organic acids or phenolic type substances. Taste and odor producing extracts that indicated a perceptible odor in odor free water in concentrations as low as 5 ppb have been isolated by means of carbon filters.

A statistical analysis (121) applied to a large number of microscopic counts of plankton in water supplies indicated that the error inherent in the counting procedure is considerably greater when the count is limited to 10 fields than the error ascribed to the sample preparation. A method was presented whereby the precision of counts may be estimated or the number of fields which must be counted to secure a given precision of analysis may be determined.

A unique device (122) has been employed by the Los Angeles Department of Water and Power in determining the temperature at various depths in reservoirs. The device called a "thermistor" employs a thermally sensitive resistor with a high negative temperature coefficient of resistance (4.4% per degree C.) which is considerably more sensitive than the commonly used fine platinum wire with a positive coefficient of resistivity (0.4% per degree C.). The device is reported to be simple and easy to operate.

Miscellaneous Developments

Among miscellaneous recent developments relating to water supply which continue to be of interest are desalting of sea water, cloud seeding to control rainfall, and the use of radioactive materials and fluorine for tracers.

Desalting Sea Water

Considerable attention has been given to the problem of producing fresh water from ocean or sea water. The use of ion exchange columns employing synthetic

zeolites and counterflow regeneration have been suggested (123) as a feasible method for converting moderately brackish waters (1500 to 2000 ppm dissolved solids) to fresh water (550 ppm or less). Ion exchange is claimed to be the most economical method of treatment of waters containing less than 2000 ppm dissolved solids. The cost is estimated to be 60 cents per 1000 gallons treated for each 1000 ppm of dissolved solids (as NaCl) removed.

Various authorities have reviewed the economies of fresh water recovery from sea water. One expert (124) concludes that of the possible methods solar distillation appears to be the most promising. Langelier (125) (126) has discussed the method of producing fresh water from sea water as announced by Ionics, Inc., of Cambridge, Massachusetts. The theory of electrochemical desalting of sea water employing ion exchange membranes was reviewed and a model unit for the process described.

A number of studies of methods for and economies of desalting sea water are in progress through research contracts financed by the federal government.

Rainmaking

There has been a continued interest in "cloud seeding" to control rainfall, but legal implications have been a discouraging factor in application of the method, particularly in the East. The work of the American Institute of Aerological Research and a general description of factors which must be considered in the successful application of cloud seeding were discussed by Krick (127) (128). He reviewed progress to date and predicted that within 10 years cloud seeding will be an indispensable tool to water users of all types. Using cloud seeding to check floods has been suggested by Vincent J. Schaefer, a pioneer of the method, but vastly more experimental work is needed before this can be accomplished (129).

New Tracer Materials

Both radioactive materials and fluorides have been used recently for tracers in water. Fox (130) has reported on using radioactive isotope to trace underground movements of water and Thomas (131) describes the utilization of such materials for ascertaining the flow pattern of water in tanks. Unquestionably many new and valuable water supply uses will be found for radioactive materials in the future.

An interesting use of fluorine in water in connection with a study of the hydraulic characteristics of the distribution system at Washington, D. C. is described by Levin and Jackson (132).

Federal Activities for Defense

The Federal Civil Defense Administration, through its Health and Special Weapons Defense Division and Engineering Services Division, has published recommendations for the emergency repair and maintenance of public water supplies (134) (135) (136), and has begun stockpiling of pipe and mobile purification equipment at strategic locations throughout the country. In collaboration with civil defense planning, the Office of Defense Mobilization, with the advice of the Facilities Protection Board, is considering measures leading toward development of an internal security program for the water works industry; also, the National Security Resources Board made preliminary investigations of the problems of water works in post-attack rehabilitation.

The Controlled Materials Plan, which was instituted by the NPA during the early phases of the Korean situation, was virtually terminated on June 30, 1953, thus allowing construction of water works and other civilian facilities without the necessity of securing allotments of materials for such projects.

In connection with the national security program, the Office of Defense Mobilization inaugurated in 1953 a program to determine the maximum mobilization of capability of the Nation's resources. In this program, consisting of an evaluation of basic manpower and material resources, various departments of the Federal Government were asked to submit estimates of mobilization requirements in terms of both dollar value and quantities of basic materials needed in their particular fields of interest and competency. For water works and sewerage, this responsibility has been assigned to the Public Health Service, Department of Health, Education, and Welfare.

Respectfully submitted,

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November 23, 1953

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